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Factors Leading to Inflation Targeting – The Impact of Adoption

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Abstract

This paper examines how the analysis of inflation targeting (IT) adoption is affected by the choice of the analyzed period. We test whether country characteristics influence the decision to apply IT differently before and after its adoption, using panel probit models for 60 countries over the period 1985-2008. Our findings suggest that there is a structural change after IT adoption, as the factors leading to adoption of IT differ significantly from those leading to its continuation. Thus, including the post-adoption period when estimating the factors of IT adoption leads to biased results when interested in the question as of why countries adopt IT.

Keywords: inflation targeting, panel probit

JEL Classification: E42, E52.

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1. Introduction

Inflation targeting (IT) is a monetary policy strategy that involves the public announcement of numerical medium-term targets for inflation and strong commitment of the central bank to achieving price stability. By the end of 2011, 31 countries had implemented IT. Due to the increasing popularity of IT, it is important to know what drives countries to its adoption.

Several studies analyze empirically the factors leading to IT choice (e.g., Mishkin and Schmidt-Hebbel, 2001; Hu, 2006; Mukherjee and Singer, 2008). However, their methodological approach does not differentiate between the factors of IT adoption and the factors of IT continuation; as a result, they simultaneously examine both. These studies commonly use the full sample for estimation, i.e., keep observations before and after adoption, until the end of the analyzed period. Such data treatment may cause endogeneity and asymmetry problems, leading to biased results.

This paper examines how the analysis of IT adoption is affected by this choice of the analyzed period. We apply panel probit models on the dataset of Samarina and de Haan (2013) and test whether IT adoption constitutes a structural change, as a result of which country characteristics influence the choice of IT differently before and after its adoption.

When analyzing the decision to apply or not to apply IT at a specific moment in time, one should take into account which monetary policy strategy a country has so far used (IT or non-IT). To put it differently, the decision to switch from non-IT to IT might not be symmetric to the decision to switch from IT to non-IT. It seems to be institutionally and politically easier to switch from non-IT to IT than vice versa. Hence, we cannot model this process symmetrically. Indeed, the asymmetry is present in real life as we do not observe (at least up to now) any transition from IT to an alternative monetary policy strategy. So far, none of the IT countries has been forced to abandon it. Thus, once a country adopts IT, the self-reinforcing mechanisms make IT endogenous and persistent (see Section 2 for further discussion).

In line with this, our empirical findings indeed suggest that the decision to apply IT is different from the decision to maintain IT. The factors related to IT differ significantly between the pre- and post-adoption periods, indicating that IT adoption creates a structural change in institutional and economic characteristics of a country. Most notably, the effect of inflation on the probability of IT adoption is largely overestimated in the model including the post-adoption period compared to the one without this period. Thus, using the full sample (i.e., including the post-adoption period) for analyzing IT adoption leads to biased parameter estimates. This bias causes an overstatement of the importance of variables that are pushed by the actual implementation of IT. Such an approach, used in previous studies of IT adoption, led the authors to overly strong conclusions.

2. Theoretical framework

IT is proved to be a durable and persistent monetary policy strategy. In over 20 years of its existence, no country has been forced to give it up.[1] The possible reason for the high durability of IT is its endogeneity. As an explanation of this endogeneity, we refer to the literature on Optimum Currency Areas (Frankel and Rose, 1996; Rose, 2000). In such studies it is argued that countries are more likely to satisfy the criteria for entry into a currency union *ex post* than *ex ante.* That is, even if a currency union is not an optimal choice for a country at the point of its accession, the process of economic and trade integration will transform the economic fundamentals and institutions in such a way that a currency union becomes an optimal regime after all. Consequently, given the self-reinforcing mechanisms and on top of that the asymmetry

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[1] Note that three EU members (Finland, Spain, and Slovakia) abandoned IT when they joined the euro area. However, this decision was not caused by unsatisfactory economic results, but rather by the institutional commitment of countries to adopt the euro and to unify their monetary policy conduct with the ECB. Thus, their choice to abandon IT was politically predetermined and can be considered as an exception. Additionally, although these EMU countries gave up explicit IT, their new monetary policy strategy under the ECB framework resembles implicit IT and might in the future be transformed into a formal IT strategy (Rose, 2007).

in political consequences, it becomes more difficult and costly to exit a currency union than to stay in.

Similar mechanisms may be at work for IT. Although some countries do not satisfy initial conditions for IT adoption, they may choose to apply IT anyway in a belief of its effectiveness in controlling inflation. Once IT is in place, country characteristics and institutions subsequently develop in a way that supports the IT framework. As institutions adjust to functioning under IT, it reinforces the decision of the central bank to maintain IT, making it an endogenously determined optimal choice. In this situation, abandoning IT becomes more difficult than keeping this strategy. The decision to give up IT after years of its implementation may undermine the credibility of the central bank and destabilize inflation expectations.

Given the endogeneity of IT, there is an asymmetry in the monetary strategy choice. That is, the (importance of) factors influencing the decision to continue or exit IT are likely to be different from those affecting the decision to adopt or not adopt IT. This asymmetry is caused by a structural change during and after IT adoption. Ignoring the asymmetry and structural change leads to biased estimation results and inadequate statistical inference.

Therefore, we test the hypothesis:

IT adoption creates a structural change in economic and institutional conditions. As a result, the factors driving IT adoption are different from those leading to IT continuation.

Special attention in this analysis is given to inflation, which is considered to be the most important factor driving IT adoption. Previous studies find that lower inflation increases the probability to adopt IT (see Samarina and de Haan, 2013). At the same time, the implementation of IT helps to maintain low inflation. As inflation after IT adoption is affected by the use of this strategy, it becomes an endogenous variable. Ignoring this endogeneity could lead to the overstatement of the importance of inflation. Thus, we expect that the effect of inflation on the probability of IT adoption is overestimated in the model that does not distinguish between the pre- and post-adoption periods.

3. Methodology

The study employs a panel binary choice model where the dependent variable y_{it} takes the value 1 if country i implements IT in year t, and 0 otherwise. We use a probit specification and estimate two types of models: (i) random effects probit to account for unobserved cross-country heterogeneity; (ii) pooled probit with standard errors clustered at the country level to control for serial correlation across time.[2] The estimation is conducted by Maximum Likelihood.

To test whether the explanatory variables influence the probability of IT choice differently before and after IT adoption, we employ a structural break analysis. Let $D(\tau)$ be a time function, where τ measures the duration of IT in years, starting from 0 in the adoption year. The unrestricted model has the form:

$$\text{Prob}\big(y_{it} = 1 \big| X_{i,t-1,}, D(\tau), \mu_i\big) = \Phi\left(\alpha + \beta X_{i,t-1} + \theta D(\tau) + \lambda(X_{i,t-1} \times D(\tau)\right) + \mu_i), \qquad (1)$$

where $y_{it} = 1$ if $y_{it}^* > 0$, $y_{it} = 0$ if $y_{it}^* \leq 0$, y_{it}^* is an unobserved latent variable which describes the decision to adopt IT; $\Phi(.)$ is a cdf of a standard normal distribution; α is a constant term; β, θ, λ are vectors of parameters to be estimated; $X_{i,t-1}$ is a matrix of explanatory variables, lagged one year, as current decisions of central banks rely on the history of analyzed factors; $(X_{i,t-1} \times D(\tau))$ is a matrix of interaction terms between the explanatory variables and $D(\tau)$; μ_i are random effects, uncorrelated with the regressors, $\mu_i | X_{i,t-1}, D(\tau) \sim N(0, \sigma_\mu^2)$.

Given that the adjustment of country characteristics to IT implementation is a gradual process, we introduce $D(\tau)$ as a smooth transition function. Such specification takes into

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[2] We do not estimate a fixed effects model for two reasons. First, there is no fixed effects probit estimator. Second, fixed effects logit drops the entire control group, i.e., all countries that did not adopt IT. For this reason, a fixed effects model has not been used in previous studies of IT adoption either.

account the fact that it may take more than one year to accommodate the economic conditions and institutions so as to be compatible with the IT framework. For $\tau > 0$, $D(\tau)$ is specified as:

1) $D(\tau) = e^{-\rho/\tau}$; $\rho \geq 0$, ρ is a decay parameter; larger ρ means a slower transition;

2) $(\tau) = 1 - e^{(-\gamma\tau^2)}$; $\gamma > 0$, γ is a speed of transition; smaller γ implies a slower transition.

During the estimation, we will use both specifications of $D(\tau)$ to examine the sensitivity of results to the choice of the smoothing function.

For the pre-adoption period, $\tau = 0$ and $D(\tau) = 0$, the estimated parameters for the explanatory variables correspond to vector β. For the post-adoption period, $\tau > 0$ and $D(\tau) > 0$, the estimated parameters are β, θ, and λ.

The restricted model has the form:

$$\mathrm{Prob}\left(y_{it} = 1 \middle| X_{i,t-1}, \mu_i\right) = \Phi\left(\alpha + \beta X_{i,t-1} + \mu_i\right). \tag{3}$$

The estimation procedure is the following: first we estimate the restricted model; then, we fit the unrestricted model with different specifications of $D(\tau)$ and use a Wald test to test for the joint significance of the interaction terms and $D(\tau)$. Testing for a structural break implies the following null and alternative hypotheses:

H_0: there is no structural break, i.e. all interaction terms with $D(\tau)$ plus $D(\tau)$ itself have jointly insignificant coefficient estimates;

H_1: there is a structural break after IT adoption, i.e. either the coefficient of $D(\tau)$ or at least one of the interaction terms are significantly different from zero.

4. Data

We use the dataset of Samarina and de Haan (2013). It consists of 60 countries over the period 1985-2008, out of which 30 countries have implemented IT and 30 countries did not. Table A1 in the Annex provides the list of countries with IT adoption dates. We conduct estimations for official adoption dates according to the central banks' documents.[3]

The dataset includes 12 explanatory variables associated with IT choice, namely: inflation, output growth, output volatility, exchange rate regime, exchange rate volatility, fiscal balance, government debt, trade openness, external debt, market-based financial structure, financial development, and an index for actual central bank instrument independence (ACBI independence). These variables are analyzed in previous studies as potential factors leading to IT adoption (e.g., Hu, 2006; Mukherjee and Singer, 2008). First, we include those 6 explanatory variables that are found significant by Samarina and de Haan (2013). These are: inflation, output volatility, flexible exchange rate regime dummy, exchange rate volatility, government debt, and financial development. Subsequently, we extend the model and examine all 12 variables. Table A2 (Annex) describes the explanatory variables.

5. Empirical results

Table 1 presents the estimation results for random effects probit models. The results for pooled probit models are reported in Table A3 (Annex). First, we fit the model with 6 and then with 12 explanatory variables. We report average partial effects at $\bar{\mu} = 0$ for random effects probit and (in Table A3) average marginal effects for pooled probit models. In the transition function $D(\tau)$ we set ρ and γ equal to 1, which implies a transition half-life (i.e. when $D(\tau) = 0.5$) of 17 months and 10 months, respectively.

The Wald test statistics indicate that all interaction terms with $D(\tau)$ plus $D(\tau)$ itself are jointly significant in the unrestricted models. Thus, we reject the null hypothesis in favor of the alternative that there is a structural break after IT adoption.

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[3] The estimation results using alternative adoption dates for soft IT and full-fledged IT are qualitatively similar and available on request.

Our results point to substantial differences between restricted and unrestricted models in terms of significance and magnitude of the marginal/partial effects for the explanatory variables. In the unrestricted models we find significant but smaller effects (in an absolute sense) for inflation, exchange rate regime, exchange rate volatility, and financial development.[4] Especially noteworthy is the finding that in the unrestricted models the estimated effects of inflation are substantially different from the restricted models, pointing to a large overestimation bias in the latter. This result is in line with our argument that the impact of inflation on the decision to apply IT changes noticeably after IT adoption. Furthermore, in random effects probit the estimates of government debt turn significant in the unrestricted models, whereas output volatility, trade openness, external debt, and market-based financial structure become insignificant. The remaining variables do not show noticeable changes. The results for the pooled probit models are comparable to the ones for the random effects probit models.

Since we cannot estimate ρ and γ directly, we conduct a robustness analysis to check how sensitive the results are to the choice of ρ and γ. Figures 1 and 2 show the estimated effects across different values of ρ and γ, respectively, that are used to measure half-lives of transition. In Figure 1 the half-life of transition varies from 3.5 months (i.e. $\rho = 0.2$) to 69 months (i.e. $\rho = 4$), while in Figure 2 the half-life of transition varies from 45 months (i.e. $\gamma = 0.05$) to 6 months (i.e. $\gamma = 3$). We show the graphs for models including 6 explanatory variables (the results using 12 variables are comparable and available on request). We find that the outcomes – with the exception of inflation – do not vary substantially across ρ and γ in terms of sign and significance of the estimated effects. For inflation, the estimated effects become much smaller (in absolute value) as transition is allowed to go faster. Moreover and as to be expected, the slower is the transition to IT (corresponding to a higher half-life of transition), the closer our

[4] The only exceptions are financial development and exchange rate variables in the unrestricted random effects probit specification with 12 explanatory variables. As compared to the restricted model, the estimated effects turn out somewhat larger in an absolute sense.

estimates get to the restricted model. However, even for a very slow transition, the results from the unrestricted models remain significantly different from the restricted.

Table 1. Estimation results – random effects probit

Variables	Restricted	Unrestricted		Restricted	Unrestricted	
		D(τ)=e $^{-1/\tau}$	***D(τ)=1-e*** $^{-\tau^2}$		***D(τ)=e*** $^{-1/\tau}$	***D(τ)=1-e*** $^{-\tau^2}$
Inflation	-3.483***	-0.566***	-0.496***	-1.788***	-0.926**	-0.876**
	(1.050)	(0.209)	(0.190)	(0.314)	(0.374)	(0.362)
Output volatility	-0.006*	0.0005	0.0005	-0.003*	0.002	0.002
	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Flexible exchange rate regime	0.094***	0.061***	0.060***	0.034**	0.071***	0.071***
	(0.035)	(0.019)	(0.019)	(0.014)	(0.025)	(0.025)
Exchange rate volatility	0.015*	0.013**	0.012***	0.008*	0.012*	0.012*
	(0.009)	(0.005)	(0.005)	(0.005)	(0.007)	(0.006)
Government debt	0.001	-0.001*	-0.001*	-0.0003	-0.001*	-0.001*
	(0.001)	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0004)
Financial development	0.118**	-0.033	-0.032	-0.058**	-0.069**	-0.066**
	(0.050)	(0.022)	(0.021)	(0.024)	(0.035)	(0.034)
Output growth				0.0001	-0.005	-0.004
				(0.002)	(0.003)	(0.003)
Fiscal balance				-0.002	-0.0001	-0.0001
				(0.002)	(0.003)	(0.003)
Trade openness				0.002***	0.0001	0.0001
				(0.0002)	(0.0003)	(0.0003)
External debt				0.0002**	-0.00002	-0.00004
				(0.0001)	(0.0002)	(0.0002)
Market-based financial structure				-0.089***	0.004	0.003
				(0.022)	(0.026)	(0.026)
ACBI independence				-0.0004	-0.001	-0.001
				(0.003)	(0.004)	(0.004)
Observations	1009	1009	1009	809	809	809
Log-likelihood	-240.0	-135.0	-128.6	-179.7	-100.7	-98.9
Wald test p-value		0.00	0.00		0.00	0.00

Notes: The Table reports average partial effects and their standard errors (in parentheses). Interaction terms are included in the unrestricted models, but not reported. ***, **, and * indicate the significance on 1%, 5%, and 10% level, respectively. Wald test p-value indicates the significance level for rejecting the null hypothesis of joint insignificance of interaction terms and $D(\tau)$.

The comparison between the restricted and unrestricted models shows that using the assumption that the factors explaining IT adoption do not depend upon the running regime is rejected by the data. Studies that rely on this assumption tend to overestimate the effects of crucial economic factors, such as inflation, exchange rate regime, financial development, fiscal discipline, and trade openness on the probability of countries to start adopting IT (see e.g., Hu, 2006; Mukherjee and Singer, 2008).

Figure 1. Average partial/marginal effects for $D(\tau) = e^{-\rho/\tau}$

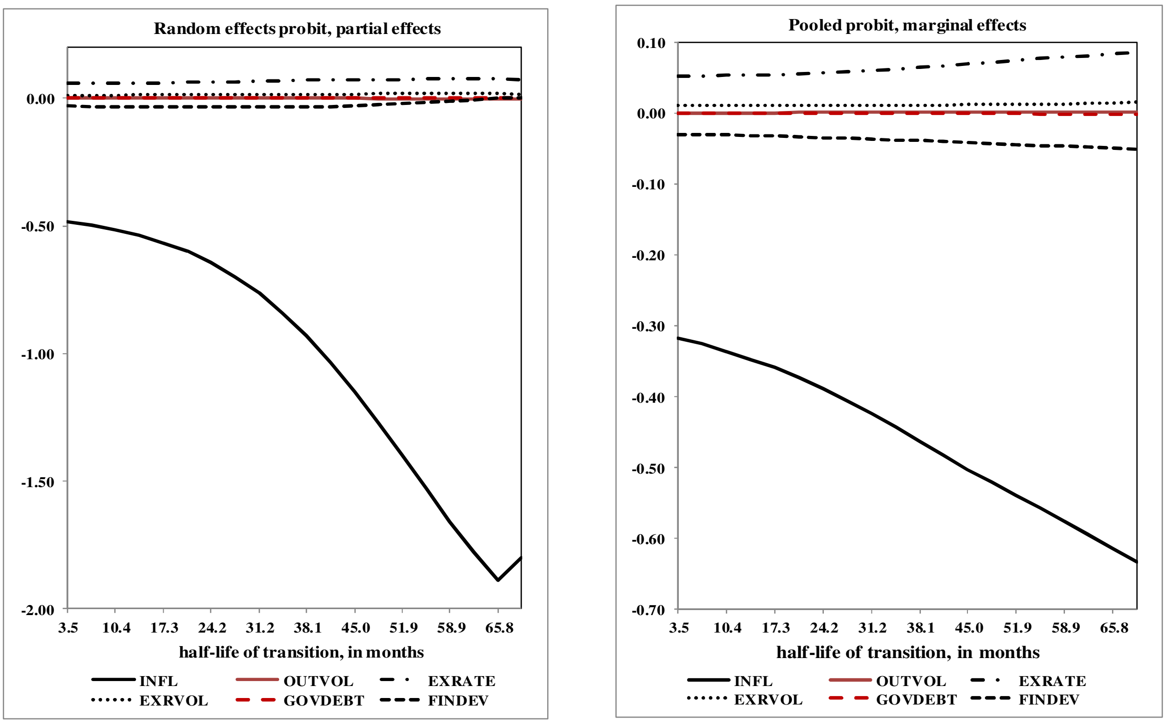
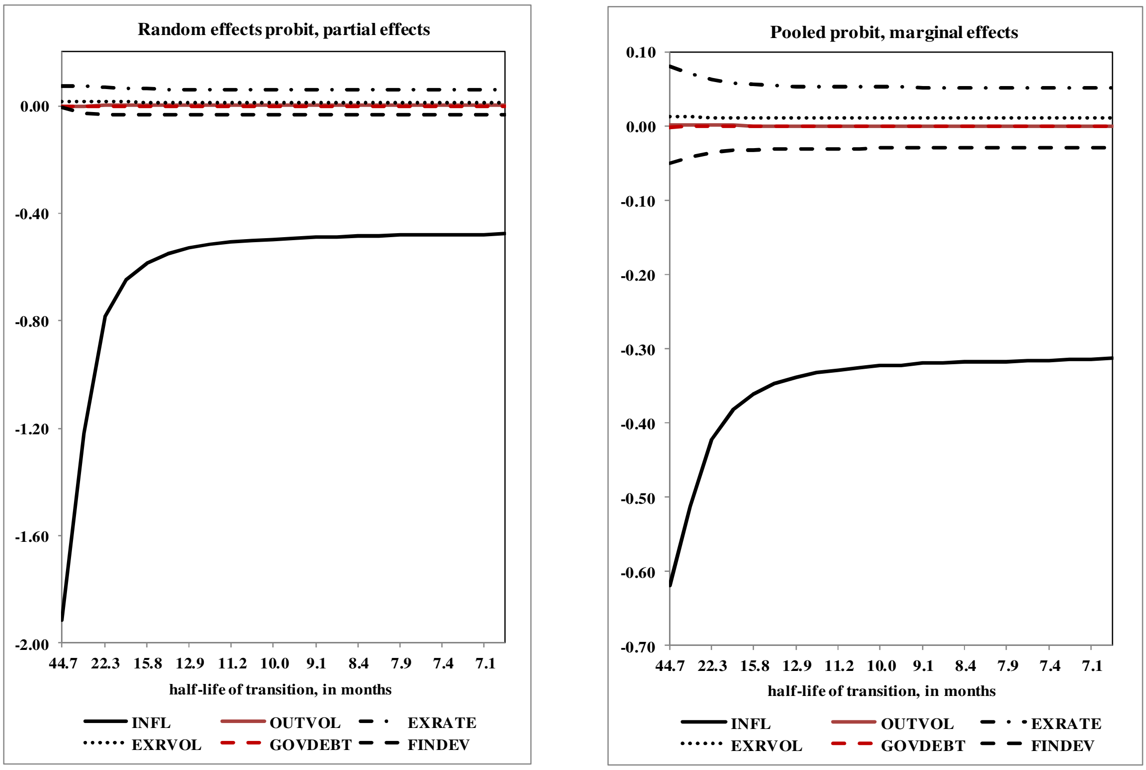


Figure 2. Average partial/marginal effects for $D(\tau) = 1 - e^{(-\gamma\tau^2)}$



To conclude, we find evidence of a structural change after IT adoption. Moreover, the effects of explanatory variables on the probability of IT adoption are in an absolute sense overestimated when we include the post-adoption period.

6. Conclusion

In this paper we examine how the selection of the time period affects the analysis of IT adoption and test whether country characteristics influence the probability to use IT differently before and after adoption. We find that there is a structural change in economic and institutional characteristics occurring during and after IT adoption. The factors leading to IT adoption differ significantly between the periods before and after adoption due to the asymmetry and endogeneity of IT. Importantly, the effect of inflation on the probability of IT adoption is largely overestimated in the model including the post-adoption period. Hence, using the full sample for analyzing the determinants of IT adoption produces biased parameter estimates. Excluding all the observations after the IT adoption date eliminates this bias.

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ANNEX

Table A1. List of countries with IT adoption dates

IT countries (30)					
Armenia	2006	Hungary	2001	Romania	2005
Australia	1993	Iceland	2001	Slovakia	2005
Brazil	1999	Indonesia	2005	South Africa	2000
Canada	1991	Israel	1992	South Korea	1998
Chile	1991	Mexico	2001	Spain	1995
Colombia	2000	New Zealand	1990	Sweden	1993
Czech Republic	1998	Norway	2001	Switzerland	2000
Finland	1993	Peru	2002	Thailand	2000
Ghana	2007	Philippines	2002	Turkey	2006
Guatemala	2005	Poland	1999	United Kingdom	1993
Non-IT countries (30)					
Austria	Greece	Netherlands	Bulgaria	Estonia	Pakistan
Belgium	Ireland	Portugal	China	India	Panama
Denmark	Italy	United States	Costa Rica	Latvia	Singapore
France	Japan	Argentina	Cyprus	Lithuania	Sudan
Germany	Luxemburg	Bolivia	Egypt	Malaysia	Venezuela

Sources: Samarina and de Haan (2013)

Table A2. Variables and their description

Analyzed factor	Description of variable
Inflation	CPI inflation rate, transformed as $\frac{\pi/100}{1+\pi/100}$
Output growth	GDP growth rate
Output volatility	Annual standard deviation of monthly Industrial Production growth rates
Flexible exchange rate regime	1 – floating exchange rate regime, 0 - otherwise
Exchange rate volatility	Annual standard deviation of monthly percentage changes in REER
Fiscal balance	Fiscal surplus (in % GDP)
Government debt	Central government debt (in % GDP)
Trade openness	Sum of export and import (in % GDP)
External exposure	External debt (in % GDP)
Financial development	Private credit by banks and other financial institutions/GDP
Market-based financial structure	1 – market-based financial system, 0 – bank-based financial system
ACBI independence	Actual index = legal index×rule of law Legal index: 1 - central bank is instrument independent, 0 – otherwise

Source: for data sources, see Samarina and de Haan (2013)

Table A3. Estimation results –pooled probit

Variables	Restricted	Unrestricted		Restricted	Unrestricted	
		***D*(*τ*)=*e* $^{-1/\tau}$**	***D*(*τ*)=*1-e*$^{-\tau^2}$**		***D*(*τ*)=*e* $^{-1/\tau}$**	***D*(*τ*)=*1-e*$^{-\tau^2}$**
Inflation	-2.651***	-0.359***	-0.323**	-3.326***	-0.417***	-0.407**
	(0.652)	(0.146)	(0.131)	(0.926)	(0.180)	(0.175)
Output volatility	-0.002	0.001	0.001	0.002	0.002	0.002
	(0.006)	(0.001)	(0.001)	(0.007)	(0.001)	(0.001)
Flexible exchange rate regime	0.236***	0.055***	0.053***	0.258***	0.059***	0.059***
	(0.058)	(0.016)	(0.016)	(0.061)	(0.016)	(0.016)
Exchange rate volatility	0.055***	0.011***	0.011***	0.060***	0.009**	0.009**
	(0.017)	(0.004)	(0.004)	(0.020)	(0.004)	(0.004)
Government debt	-0.002	-0.001**	-0.001**	-0.002	-0.001**	-0.001**
	(0.002)	(0.0003)	(0.0003)	(0.002)	(0.0004)	(0.0004)
Financial development	-0.082	-0.032*	-0.030*	-0.154*	-0.046**	-0.045**
	(0.080)	(0.019)	(0.018)	(0.092)	(0.019)	(0.018)
Output growth				-0.002	-0.003	-0.003
				(0.008)	(0.002)	(0.002)
Fiscal balance				0.014	0.002	0.002
				(0.010)	(0.003)	(0.003)
Trade openness				-0.0003	0.00001	0.00003
				(0.001)	(0.0002)	(0.0002)
External debt				0.0003	-0.00001	-0.00001
				(0.005)	(0.0001)	(0.0001)
Market-based financial structure				0.047	0.016	0.015
				(0.084)	(0.016)	(0.016)
ACBI independence				-0.00001	-0.0003	-0.001
				(0.017)	(0.003)	(0.003)
Observations	1009	1009	1009	809	809	809
Log-likelihood	-468.8	-139.8	-132.2	-396.1	-104.4	-101.9
Wald test p-value		0.00	0.00		0.00	0.00

Notes: The Table reports average marginal effects and their robust standard errors (in parentheses). Interaction terms are included in unrestricted models, but not reported. ***, **, and * indicate the significance on 1%, 5%, and 10% level, respectively. Wald test p-value indicates the significance level for rejecting the null hypothesis of joint insignificance of interaction terms and $D(\tau)$.

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